Louisiana Coastal Area (LCA), Louisiana

Ecosystem Restoration Study

July 2004

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Appendix A – Science and Technology Plan

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LOUISIANA COASTAL AREA (LCA), LOUISIANA

ECOSYSTEM RESTORATION STUDY

APPENDIX A

SCIENCE AND TECHNOLOGY PLAN

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1.0 INTRODUCTION

The science of ecosystem restoration is evolving rapidly through theoretical and applied research. The body of scientific knowledge and data for coastal Louisiana has advanced sufficiently to provide a sound basis for implementation of restoration projects incorporating a number of technological and engineering solutions with continuous learning and method improvement. However, certain aspects require increased data and monitoring, modeling, and research and experimentation to decrease uncertainties, especially in the area of predicting ecosystem response to the restoration projects. The Louisiana Coastal Area Ecosystem Restoration Plan (LCA Plan) Science and Technology Plan (S&T Plan) supports the restoration efforts on both fronts. It also supports the opportunity to perform restoration projects in the near-term and thus slow overall coastal degradation while concurrently pushing forward the cutting edge of restoration science, to reduce uncertainty, and rapidly improve the effectiveness of all future restoration activities.

The LCA Program Execution Team requires a formal, clear, concise, and effective process to use all appropriate scientific and technological resources to determine the managerial, non-structural, and structural actions to attain ecosystem restoration goals. The S&T Plan includes the rivers, interior wetlands, open bays, barrier islands, and near-shore environments of Louisiana and contributing watersheds, which are all organized into a hierarchical systems-level approach for restoring and managing Louisiana's deteriorating coast. A fundamental and symbiotic relationship exists between this S&T Plan and the LCA Program Execution Team and other coastal protection activities at the state, local, and Federal level. This S&T Plan reaffirms the need for close and continuing coordination between the scientific community, state and Federal coastal resource managers, and the LCA Program Execution Team.

1.1 Background

Scientists have long recognized the importance of the Louisiana coastal area for fish and wildlife habitat (Coalition to Restore Coastal Louisiana, 1989; Keithly, 1991; Herke, 1993; Michot, 1993), estuarine productivity (Morris, et al., 1990), and ecological sensitivity to human disturbances (Templet and Meyer-Arendt, 1988; McKee and Mendelssohn, 1989; Reed, 1989). This recognition has resulted in considerable efforts to investigate and understand the complex physical (Morris, et al. 1990), chemical (Mendelssohn el al., 1981; Morris, 1991), and ecological (Montague, et al. 1987) processes that drive the system, providing Louisiana with a rich history of scientific

studies. Studies on understanding relationships between different habitats and different aquatic species (Minello and Zimmerman, 1991) have been conducted due to the importance of the Louisiana coast's support to numerous estuarine dependent fish and its ability to provide important nursery habitat for diverse fish communities. The coastal areas have also been important for wintering waterfowl with several studies conducted to understand relationships between waterfowl use and habitat conditions. Oil and gas exploration and production have prompted numerous studies on subsurface geologic conditions (Wallace, 1966). Additional geologic conditions have been investigated to aid in understanding deltaic processes that have shaped the Louisiana coast (Fisk, 1944; Kolb and Van Lopik, 1958; Frazier, 1967; May, 1984; Smith et al., 1986; Penland et al., 1988; Dunbar et al., 1994; 1995). Studies on the Atchafalaya River and delta have also contributed to our understanding of deltaic processes (U.S. Army Corps of Engineers, 1951; Fisk, 1952; Shlemon, 1972; Wells and Roberts, 1984; Smith et al., 1986). In addition, numerous studies performed in other ecosystems are applicable to some degree in understanding the ecology and function of the Louisiana coastal area. The results of these investigations provide considerable understanding of the physical, chemical, and biological processes underway within the Louisiana coast. The numerous State-sponsored studies generated from the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) program have developed basic trend information over the last ten years. Studies funded by the National Science Foundation and others have aided in understanding impacts and provided recommendations for improved operations for some existing large water diversion projects.

Although many studies have been conducted in the Louisiana coastal area, most were limited in geographic extent or technical scope. Therefore, while much has been learned from previous efforts, many scientific and technical uncertainties remain. The LCA Plan builds upon a sizable knowledge base, but additional investigations to further reduce the scientific and technical uncertainties and to enhance the likelihood of projects successfully meeting restoration goals would be necessary during later LCA Plan implementation. The LCA Project Delivery Team (PDT) reviewed annual adaptive management reports prepared to assess previously constructed CWPPRA projects. These efforts to identify lessons learned from the many CWPPRA projects, past and future, will also serve as a valuable assessment of what worked and why. Identification of reasons why some projects did not meet project goals would also be very beneficial in reducing potential uncertainties associated with future projects.

Louisiana natural resource managers have also long recognized the magnitude of coastal degradation (Barras, et al., 2003; Barras, et al., 1994; Dunbar, et al., 1992) and have undertaken substantial efforts to address this problem. Advocacy groups have been formed for wetland protection and restoration. Federal and state statutes authorize and finance Louisiana coastal wetland restoration efforts on a large scale (Boesch, et al. 1994). Small-scale restoration projects proliferated throughout the 1990's, as scientists inside and outside of government continued to press for measures to address the land-loss problem regionally, as well as the related issues of offshore eutrophication and hypoxia (Coalition to Restore Coastal Louisiana, 1998).

In spite of these efforts, wetland losses have continued at a significant rate, computed to be 23.9 mi^2 (61.9 $km^{2)}$ during the last 10 years (See Appendix B for more details.) Now more than ever, sound science is needed to support broader, systems-level, integrated coastal restoration to implement the LCA Plan.

A significant component of implementing the LCA Plan is a sound approach to continually incorporate the best science and technology into project design, implementation, and monitoring for restoration and rehabilitation of the ecosystem. The first four sections of this S&T Plan provide a framework for identifying science issues and for improving coordination of scientific activities to support the LCA Program Execution Team along with other federal, state, local, non-governmental and academic efforts. These sections should remain relatively constant as a guiding strategy for the S&T Plan. Section five provides an approach for execution of the S&T Plan, and lists the general types of studies to be conducted and subsequent studies focused on issues of uncertainties. Section 5.0 will be continuously reviewed and updated annually, to assess implemented project outputs and to incorporate lessons learned using the adaptive-management strategy to improve Program Management for subsequent years. Lastly, this S&T Plan will be periodically reviewed and updated to reflect advances in science and technologies.

1.2 Objectives of the Science & Technology Plan

The objectives of the S&T Plan are to provide a strategy, organizational structure, and processes to facilitate integration of science and technology into the decision-making process with Program Management, the Program Execution Team (See Management Section in LCA Main Report for definition.) and the Science and Technology Program (S&T Program) (**figure A-1.1**). Implementation of this S&T Plan would ensure that the best available science and technology are available for use in the design, construction, and operation of LCA Plan projects. This S&T Plan incorporates a process called "adaptive management" – an iterative approach for improving science information and inserting it into management decisions. Therefore, as decisions are implemented based upon best available science, a structure and process must be in place to acquire better information and adjust the implemented actions accordingly to improve the probability of achieving the goals and objectives for implementation of the LCA Plan. Such a process requires the development of key tools – such as development of baseline data and monitoring over time and space, models, data management, and continued research – to provide managers and users with updated information for planning restoration and on the effects of management actions designed to achieve restoration. By participating in and providing information for restoration efforts, scientists can help define and measure the progress of restoration and the success of individual restoration projects and plans.

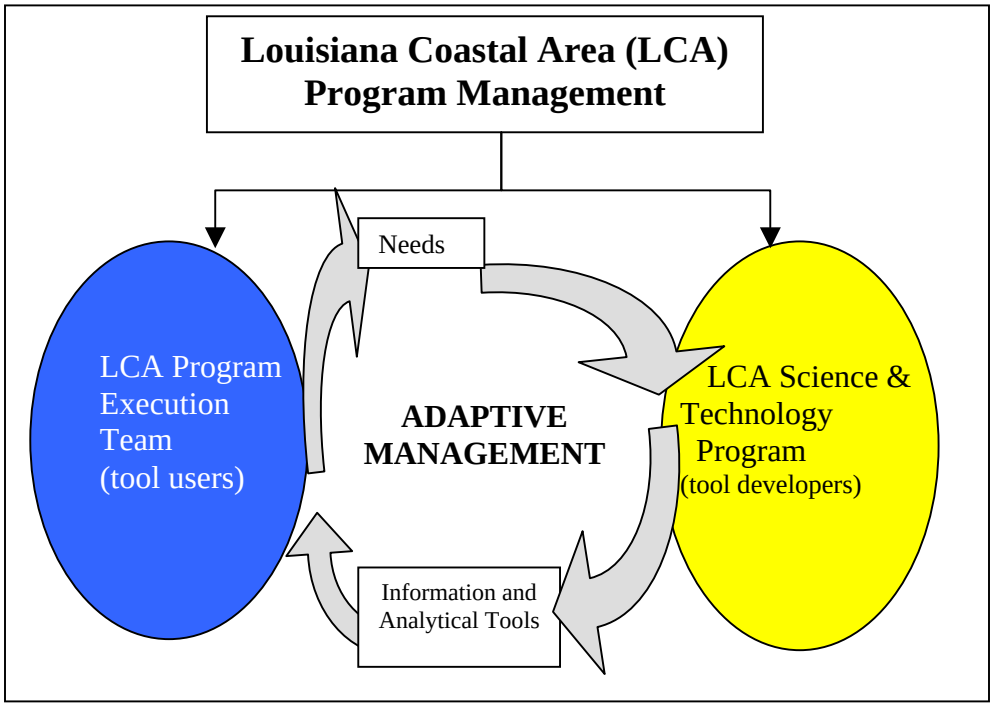

Figure A-1.1. Louisiana Coastal Area (LCA) Program Management. The Program Execution Team will implement the LCA Plan with technical support from the LCA S&T Program. Communication between the Program Execution Team and the S&T Program will be achieved using an adaptive management strategy.

An effective science program should perform the following:

- Work with LCA Program Management and the LCA Program Execution Team to review and assess goals, objectives, and key documents of the LCA Program,
- Identify science needs to assist the LCA Plan in meeting those goals and objectives,
- Establish and maintain independent science and technology advisory and review boards,
- Manage and coordinate science projects for (1) data acquisition and monitoring, (2) data management, (3) modeling, and (4) research to meet identified scientific needs of the LCA Plan,
- Through scientific evaluations, assessments and peer reviews, assure science implemented, conducted or produced by the S&T Program meets an acceptable standard of quality, credibility, and integrity,
- Establish performance measures for restoration projects and monitor and evaluate the performance of program elements,
- Improve scientific understanding of coastal restoration issues within the context of Adaptive Environmental Assessment and Management and infuse this

improved information into planned or future restoration planning, projects and processes conducted by the Program Execution Team,
- Prepare scientific documents including a periodic Science and Technology Report and conduct technical workshops and conferences, and
- Provide reports on science projects to support the Government Performance and Results Act (GPRA).

The intent of this S&T Plan is to provide a foundation, organizational structure and processes for continual dialog among scientists, the Program Management Team, and the Program Execution Team. Priorities for science and technology are established based on the needs of the Program Execution Team (tool users in **figure A-1.1**), as they relate to restoration goals. Priorities are also be based on the needs of Program Management and will be responsive to programmatic, coastwide issues, as well as project-specific issues.

1.3 Role of Science in Ecosystem Rehabilitation and Restoration

The need for a solid scientific foundation to support system-scale ecological restoration has been broadly recognized through similar programs and in statements of agency leaders. Restoration actions are frequently initiated because of societal perceptions rather than in response to a clear, scientifically defined, environmental concern. In the past, restoration managers often relied upon professional opinion to design, implement and manage projects but today's managers realize the value of a continual flow of science information to guide planning, construction and management of restoration projects. The credibility of complex ecosystem restoration programs and the ultimate success of the restoration effort require that science information be made available in a timely fashion and in useful formats to decision makers. An early and fundamental role for science is to provide an understanding of system functions as the basis for determining what processes and attributes need to be restored or managed.

The role for science then is not to make the restoration and management decisions but to:

- Improve coastal restoration decision-making, by identifying science issues to be addressed and develop science information for restoration managers,
- Provide scientific data, analysis, and interpretation that are critical to the planning, design, construction and operation of restoration projects,
- Develop tools, methods, and protocols for system and project -level restoration planning and assessment,
- Minimize uncertainties about the system or system components, which limit restoration planning and execution,
- Assess the immediate and long-term effectiveness of restoration actions in meeting program goals, and
- Provide information and synthesis in a timely manner and useful formats.

There is also growing recognition that restoration efforts simply would not succeed without a sound scientific foundation. These include: (1) placement of the science and technology program in the organizational structure where it can influence decisions, (2) development of relevant science information delivered to managers in a timely manner and useful format, and (3) a commitment to continuous review of monitoring data from restoration projects to adapt their operation and development, as well as the design of future projects, based upon system responses. The LCA Plan approach is based on using the best information in an adaptive management setting, and this S&T Plan demonstrates how these challenges would be overcome as the LCA Plan is implemented.

1.3.1 S&T Program Structure

There are five primary components in this S&T Plan and each component has a different emphasis and requirement. These include: (1) Science Information Needs, (2) Data Acquisition and Monitoring, (3) Data and Information Management, (4) Modeling and Adaptive Management, and (5) Research. Determining science needs requires a continuous process in place that solicits science needs from Program Managers, the Program Execution Team, and scientists. Data Acquisition and Monitoring require standard operating procedures and rigorous adherence to those standards. Data and Information Management requires standards and procedures to assure data can be shared or compiled from a variety of sources. Modeling and Adaptive Management requires broad interactions among scientists, Program Management, and the Program Execution Team. Research requires clear hypothesis testing and a substantial degree of scientific independence but close coordination with the Program Execution Team.

1.3.1.1 Science information needs

The S&T Program, working closely with LCA Program Management and the Program Execution Team, would develop processes to determine science needs. The S&T Program would also assure that both scientists and the Program Execution Team are involved in establishing needs, ranking the importance of each need, and determining feasibility. This is envisioned as a continuous process that is repeated each year for the coast as a whole and more often for solving specific problems. While the emphasis on coastal restoration is an integration of science disciplines, this process must also determine science needs while ranking importance and feasibility on a discipline-by-discipline basis. Broadly this includes disciplines such as:

- Hydrology (flows in rivers, open water and bays, salinity, sediment loads and flows, water quality, nutrients, and storm effects),
- Biology and ecology (mapping habitats and trends, ecological processes and functions and values, species and habitat requirements and restoration, invasive species),
- Geography (base maps, satellite maps, aerial photography, land loss trends, elevation, and bathymetry),

- Geology (barrier island processes, sand sources, faulting, subsidence processes, oceanic processes),
- Oceanography (hypoxia, and oceanic processes),
- Meteorology (weather and storm patterns and intensity),
- Sociology (Cultural change and trends),
- Economics (Effective costs or savings of restoration), and
- Information technologies (Computer systems, geographic information systems, communications, data storage and retrieval, and standards).

1.3.1.2 Data acquisition and monitoring

To be effective in providing data and information to Program Management and the Program Execution Team, this S&T Plan would consider data needs in a geographic hierarchy for the purposes of restoration planning, construction, management and maintenance, and monitoring the relative success of projects. Project success would be measured, not only on a project-by-project basis, but also on its contributions to both basin or sub-basin levels, and entire ecosystems (e.g. Mississippi Deltaic Plain or Chenier Plain). To accomplish this, the S&T Plan would strategically develop, as needed, monitoring systems and collect data within the different ecosystems and integrate this effort with the other ongoing monitoring systems like the CWPPRA Reference Monitoring System for Wetlands as appropriate.

1.3.1.3 Data and information management

The data and information available through numerous agencies and organizations include historic coastal Louisiana datasets, ongoing monitoring collections, and new data collections generated from new restoration projects and science programs. A data and information management system is needed to provide scientists and project managers with decision-support tools to compare historic trends and management strategies with current restoration techniques. This network of geospatial and scientific data would allow project managers to incorporate lessons learned and adjust restoration strategies to best achieve management goals. The data and information framework may be a collaborative effort involving government and private organizations. The end product would be a distributed network of data centers sharing common data structures and standards.

1.3.1.4 Modeling and adaptive environmental assessment and management

Adaptive Environmental Assessment and Management (AEAM) prescribes a management process wherein future actions can be changed by observing the efficacy of past actions on the ecosystem through the use of monitoring and modeling. The efficacy is determined through monitoring and other means to improve the response of the system (Holling and Gunderson, 2002). The adaptive approach recognizes that uncertainty is unavoidable in managing large-scale ecological systems. However, if properly planned and maintained, the feedback element can be used to sequentially improve management actions so that future system conditions become more consistent with program goals and

objectives than past actions. AEAM allows development of an iterative and flexible approach to management and decision-making.

1.3.1.5 Research

There are many kinds of science needs that must be pursued through a research and hypothesis or experimental testing process. There is also a danger that research would be conducted for research sake without close adherence to the needs of the program execution. Therefore, it is imperative that the S&T Plan focuses primarily on the needs of the Program Execution Team, but allowing for opportunities within the S&T Plan for creative studies or testing of new technologies that may have utility for future projects. In general, research projects have a variety of possible outcomes and often a substantial amount of uncertainty, and as a result require a great deal of scientific independence. This includes restoration demonstration projects, field or laboratory projects, new technology demonstration projects, characterizations of project areas, or improving our understanding of natural and human caused processes that affect restoration and answer scientific uncertainties. Activities not related directly to the needs of the Program Execution Team would be coordinated and approved by the Program Manager.

1.4 Communication

While scientific understanding of restoration issues has improved, significant gaps remain in the scientific information and adaptive management tools needed for large-scale coastal restoration. Program Management, the Program Execution Team, and the S&T Program (**figure A-1.2**) would coordinate to ensure that the goals and objectives of the LCA Plan are achieved using the best available science. The Program Execution Team and the S&T Program are generally interconnected as follows: the LCA Program Execution Team, representing those needing and using the science information and are the tool users; and the S&T Program, representing those providing the science information and are the tool developers as indicated in **figure A-1.1**. Scientific information would be provided in the adaptive management framework, through monitoring and periodic interpretation, model analysis, and continual improvement in knowledge and methods by supporting research, and interaction between scientists and restoration managers. The framework also provides mechanisms for periodic independent peer review to ensure high standards of scientific investigation. The S&T Plan establishes a framework in which study components are integrated to ensure that sound science directs appropriate restoration choices and long-term environmental sustainability.

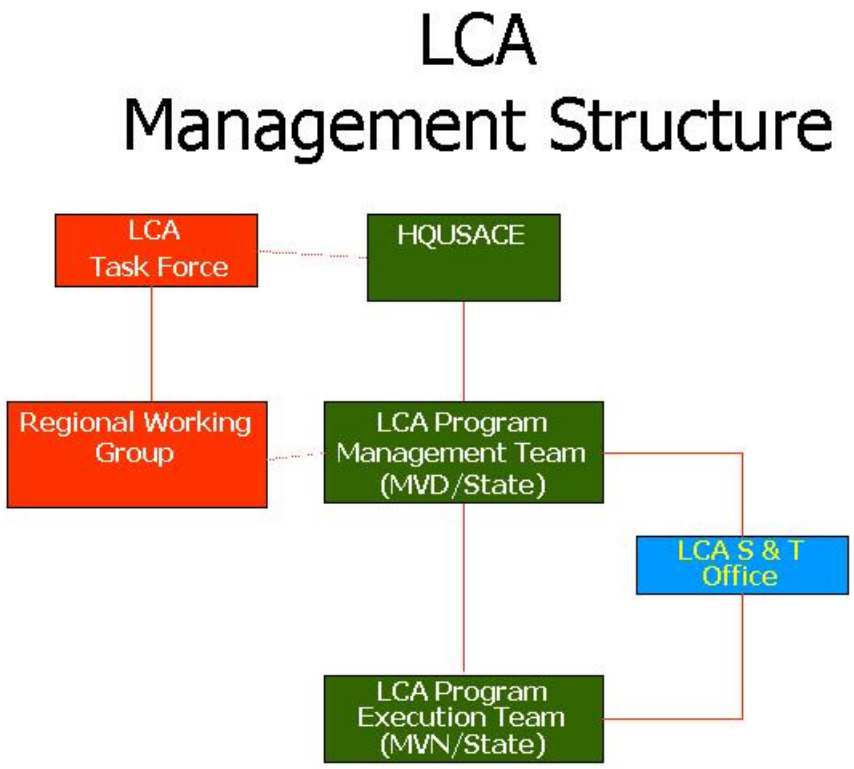

Figure A-1.2. LCA Management Structure. This figure presents the lines of communication between the LCA Program Management Structure and the S&T Office.

This S&T Plan provides a strategy, structure and process to incorporate scientific rigor into the LCA Plan. The S&T Plan also provides a detailed approach for data acquisition and monitoring, data management, modeling, and research activities that support management decision-making. The S&T Program would inventory germane programs and activities, identify data gaps and limitations, and outline actions and resources needed to overcome those gaps and limitations.

The S&T Plan, executed through the LCA Science and Technology Office (**figure A-1.2**), provides mechanisms of coordination that are necessary to ensure timely information transfer to both decision-makers and the Program Execution Team, and to identify resource needs required to provide the scientific information necessary to implement the LCA Plan. The S&T Plan ensures data management and synthesis processes that facilitate information sharing and periodic reporting. An important component of coordination is the timely and accurate identification of data gaps that would be addressed through hypothesis testing. Subsequently, the S&T Plan incorporates independent, technical review committees and advisory boards, and periodic reviews of existing data through coordination meetings and conferences. The S&T Plan would be reviewed annually and updated as part of the adaptive management strategy.

1.5 Science & Technology Program Approach

1.5.1 Science & Technology Plan Development Process

Formalization of a science-based program for the LCA Plan and the institutional framework for management of a mission-directed program of data acquisition/monitoring, research, and modeling, model development, and assessment requires an interdisciplinary and interagency approach. Moreover, successful management of these efforts requires the clear articulation of science and management needs, and ultimately, the agreement of how those needs are organized, prioritized, and accomplished. Therefore, an early step taken to construct the S&T Plan was to conduct a workshop for scientists from Louisiana and across the nation to provide suggestions that could be used by the Corps and State to identify data gaps and enhance development of a science-based Adaptive-Management Decision-Support System. Additionally, a review was conducted of other similarly large ecosystem restoration programs (i.e., Everglades, CALFED, and Chesapeake Bay) to assess lessons learned and to provide direction for development of the S&T Plan proposed herein. The review was an opportunity to examine lessons learned by others and to build upon the strengths of those programs to develop and implement the adaptive- management strategy presented in this S&T Plan. Subsequently, several additional meetings were held with representatives from Federal and state agencies and academia to discuss the goals and objectives of such a S&T Plan and to develop an overall strategy and organizational structure for the S&T Plan. Representatives from the meetings prepared draft sections of this S&T Plan.

1.5.1.1 Strategy

A basic premise of the S&T Plan is that it would be based on *Adaptive Environmental Assessment and Management* (See Section 2 of this Plan for a more detailed discussion.). All work covered by this S&T Plan would be both scientifically defendable and yet relevant to the overall program needs of the LCA Plan. This means that all scientific activities would be conducted in a manner true to scientific principles and methods, but with recognition of the practical and applied destination of the results. This S&T Plan would be implemented in close coordination with LCA Program Management and the Program Execution Team to cover all scientific studies: investigations, data collection, simulations, analysis, modeling, and evaluations sponsored either directly through LCA Plan or conducted in support of the program by coordinating partners. Work conducted through this S&T Plan would comply with generally recognized *Scientific Guiding Principles* and be directed, executed, and reported through a well-defined *S&T Program Structure*.

15.1.2 Science guiding principles

All work would be conducted in compliance with the following Guiding Principles.

1) All scientific work would be ***Responsive*** to and prioritized according to the LCA Plan ***needs.***
2) A strategy of ***Science Leadership and Engagement with the Program Execution Team in Adaptive Management*** would continue to be integrated throughout execution of the LCA Plan and the S&T Office.
3) ***Clear lines of Communication*** would be established and maintained between all members of the scientific team, LCA Program Management, the LCA Program Execution Team, external advisors, and the public as appropriate through a coordinated effort.
4) Scientific activities would promote ***Multiple Discipline Integration*** to optimize synergy and early resolution of potential technological conflicts.
5) The scientific process would be ***Transparent*** with all steps, assumptions, and products available for professional and public scrutiny.
6) All science work would be based upon the ***First Principles***, i.e., incorporate the fundamentals of biology, physics, and chemistry while maintaining temporal and spatial-scale relationships among all variables and comply with the scientific method.
7) Work would be conducted within the context of ***Building Institutional Learning and Scientific Capabilities*** that would provide continuing future technological benefit to the Louisiana coastal area and the study partners.
8) The current ***State of the Technology*** would be applied and transferred into application, but advances in technology would continuously be examined and integrated as appropriate.
9) ***Resources would be Leveraged*** across the various agencies and study partners to promote fiscal responsibility.
10) A ***Peer Review*** process would be established and followed to include research proposal evaluations, in-progress review, and product quality assessments.
11) All members of the S&T Program would be ***Accountable*** for the integrity, quality, ethics and appropriateness of their work.

1.6 Science and Technology Plan Organization

This S&T Plan consists of five sections. Section 1 provides a short background on the problems and challenges of the LCA Plan. It also includes the objectives of the S&T Program, addresses why science is an integral part of the LCA Plan, discusses lines of communication between the S&T Office, Program Management, and the Program Execution Team, and finally provides general guiding principles of the S&T Program. Section 2 discusses the concepts of Adaptive Environmental Assessment Management and strategies for integration of science into the LCA Plan. Section 3 discusses the organizational structure of the S&T Program, its components, and relationship to the LCA Plan. Section 4 identifies some of the scientific uncertainties associated with many of the potential near-term course of actions. Those uncertainties provide the focus of the

S&T Office, particularly during the early years of the S&T Program. This section also provides some examples of potential demonstration projects and the uncertainties to be addressed with those projects. Section 5 of this S&T Plan identifies the assumptions and objectives considered to execute the S&T Plan, a general strategy for Plan development, and more specific tasks to be executed during the first three years of the S&T Program. As one might expect, the level of detail in Year 1 of the Plan is greater than that presented in subsequent years.

Therefore, the first four sections of the S&T Plan collectively provide the foundation for the LCA S&T Program and are not expected to change dramatically from year to year, particularly after the first couple of years. However, Section 5 would be reviewed and refined annually to reflect lessons learned during program planning and execution. It would continuously be reviewed within the S&T Office to build upon our understanding of ecosystem processes and responses and to constantly reduce scientific uncertainties associated with operation of ongoing projects and planning and execution of future projects. This process of learning while doing would be integrated throughout the LCA Plan, and would be integral to effective and responsive execution of the S&T Program.